HWRF Testing and user support at the Developmental Testbed Center

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In collaboration with

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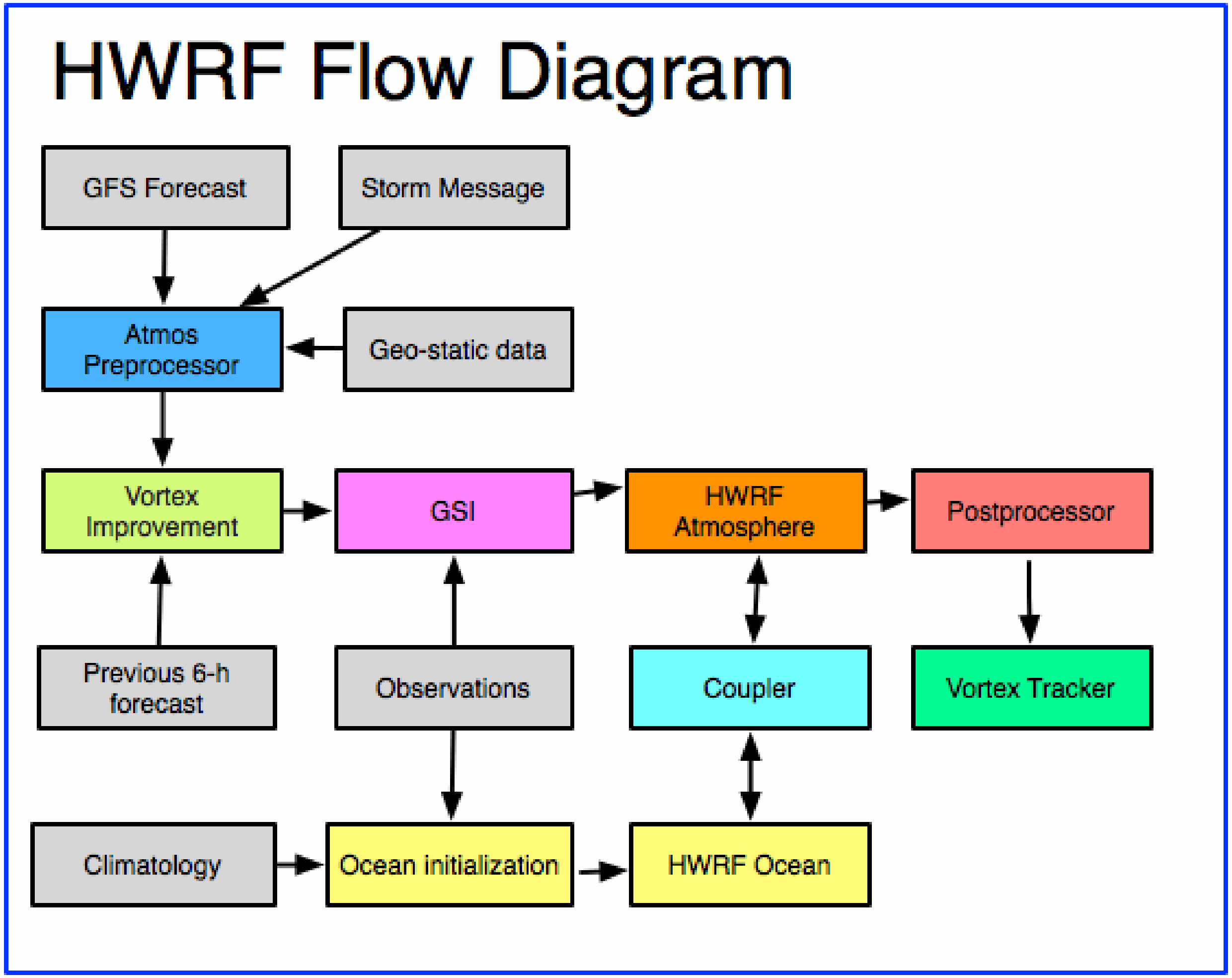
Developmental Testbed Center

Hurricane WRF components



HWRF Components

WRF model

Pre-Processor (WPS)

Vortex initialization

Data assimilation (GSI)

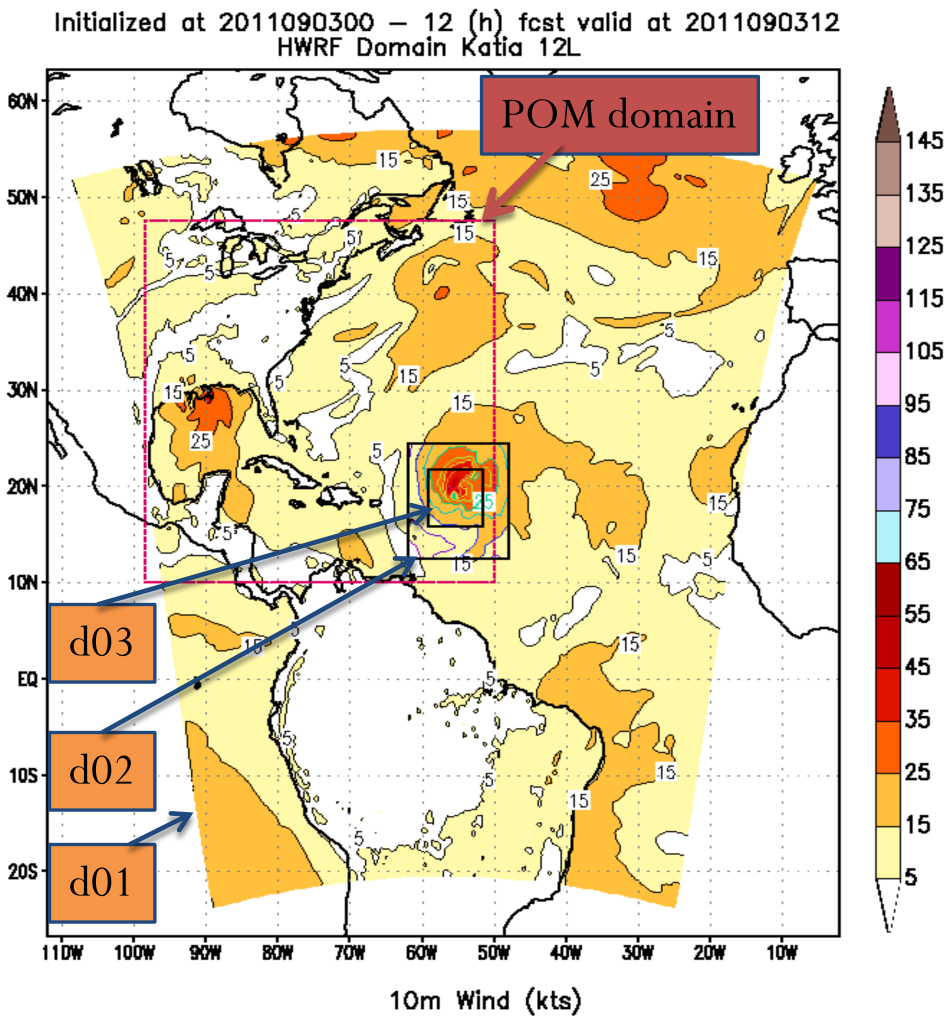
Coupler (NCEP)

Ocean (POM-TC)

Post-Processor (UPP)

Vortex Tracker (GFDL)

HWRF 2012 grid configuration



Atmospheric configuration

- Horizontal grid spacing: 27, 9, 3 km
- Inner nests move to follow storm
- Domain location vary from run to run depending on storm location
- 42 vertical levels
- Model top 50 hPa

Oceanic configuration

- Horizontal grid spacing: 18 km
- Size, location of grid depends of location of storm
- Pacific
  - 1-D (column) model
  - 16 vertical levels
- Atlantic
  - 3-D model
  - 23 vertical levels

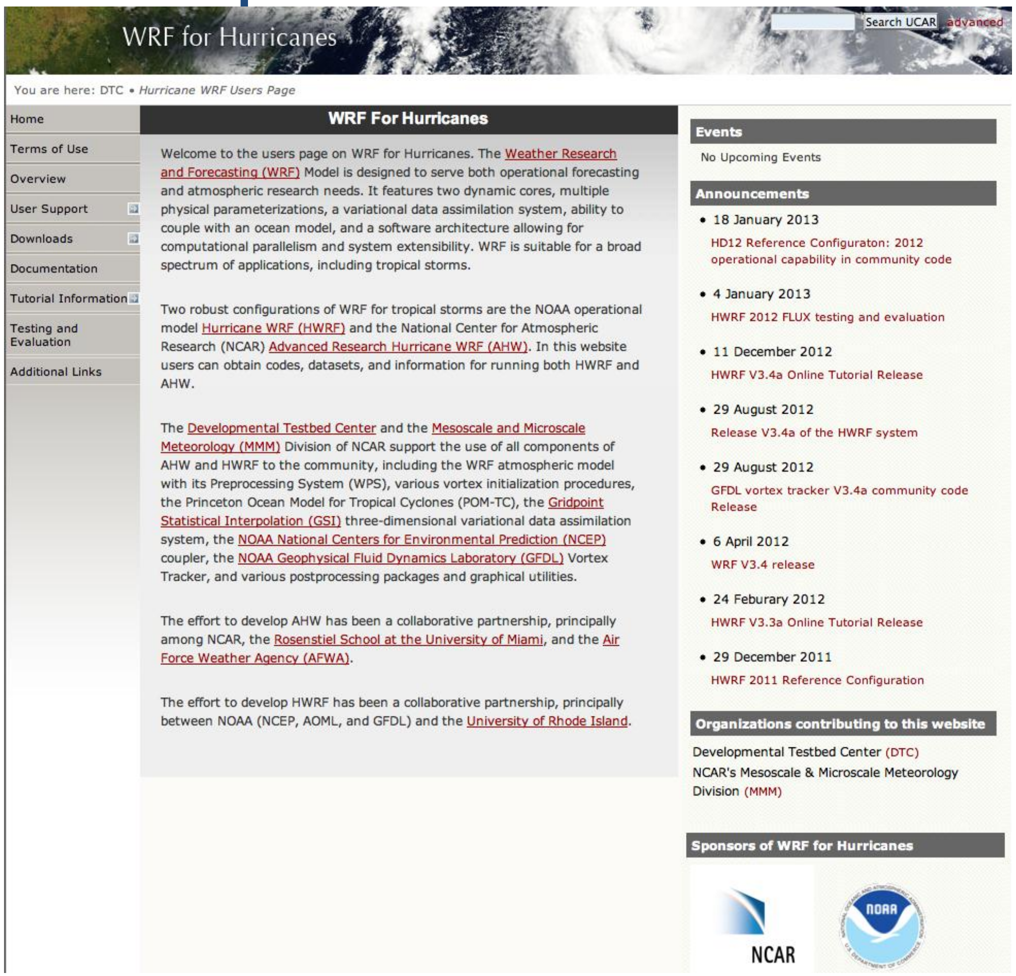
DTC Goal: Tech Transfer to Hurricane NWP

Current focus in Hurricane WRF model

1. **User Support**
   - Support the community in using an operational hurricane model
2. **Code Management**
   - Create a framework for NCEP and the research community to collaborate; maintain the code unified
3. **Testing and Evaluation**
   - Perform tests to assure integrity of community code and evaluate new developments for potential operational implementation

www.dtcenter.org/HurrWRF/users

Developmental Testbed Center support



Code downloads, datasets, documentation, online tutorial, helpdesk

500 registered users

Yearly releases corresponding to operational model of the year

Stable, tested code

Benchmarks available

Current release: HWRF v3.4a (2012 operational)
Next release: HWRF v3.5a (2013 operational) – June 2013

Code Unification

Motivation: assure that the code used operationally by HWRF developers, community, and operations does not diverge

Approach: single code repo hosted at DTC links to community codes

- Complex as HWRF components are used by many other groups
- Requires a lot of checks to make sure HWRF code does not get "broken" by outside contributions
- WRF component of HWRF remained "isolated" 2007-2010, but was integrated in the general WRF repository in 2011, opening many doors for collaborations

Access to developmental codes

Motivation: developers need to collaborate in experimental code

Approach: support developers get/deliver code to centralized location

For HWRF friendly developers, DTC/EMC now provide

- Access to the unified HWRF code repository hosted by DTC
- Access to the latest experimental codes
- Ability to create your own branch, with a clear path to incorporate development in the centralized code
- Synchronization of developmental and community codes
  - Prevents HWRF developmental code from aging off
  - Provides collaboration opportunities

Currently supporting 63 friendly developers

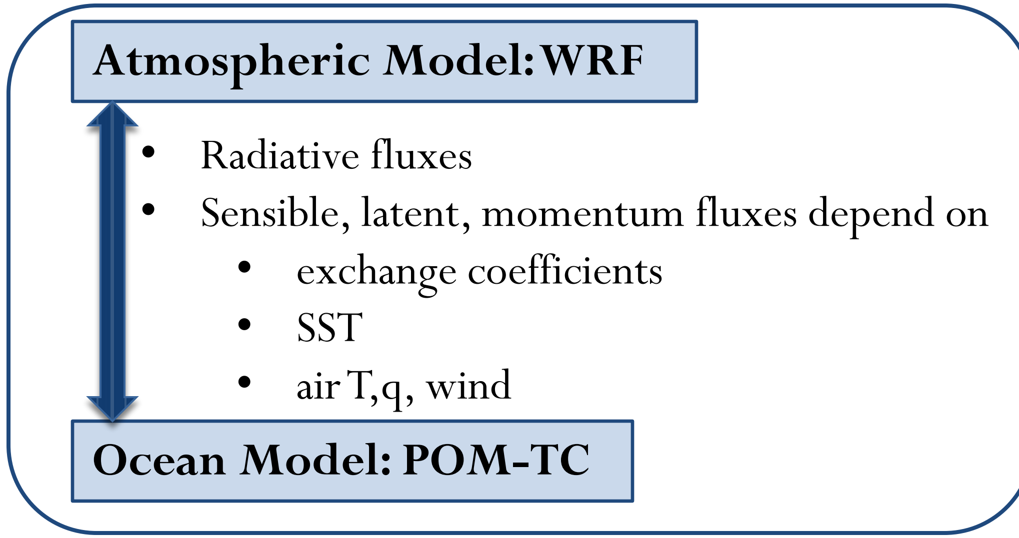
HWRF Testing in DTC (2012)

- **Case studies**
  - Alternate physics (Thompson MP & RTMMG radiation)
- **Diagnostics**
  - Comparison of large scale fields against GFS analyses
- **Comprehensive T&E**
  - Sensitivity to cumulus parameterizations
  - Change in momentum flux in ocean model
    - Topic of remaining of this presentation

More information at dtcenter.org/HurrWRF/users

Ocean model in HWRF

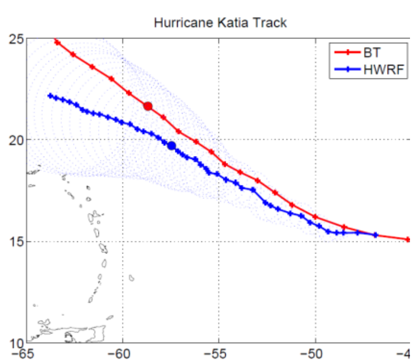
- Allows greater accuracy in
  - SST field
  - Latent/sensible heat fluxes
  - Intensity
- Can represent
  - Turbulent mixing (1D), upwelling and advection (3D)
- Causes SST cooling as cold water below surface is transported up
- Is crucial because SST can change rapidly under tropical cyclones



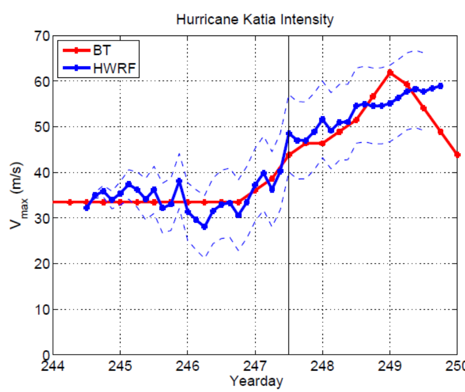
Background

- Coupled HWRF tests (2007) indicated POM-TC **over-cooling**
- To minimize over-cooling, HWRF fluxes to POM-TC were reduced by 25%
- Yablonsky et al. (2010 IHC): confirmed POM-TC tended to **over-cool** in response to prescribed wind stress based on observed TC winds, when compared against buoy composites
- Uhlhorn and Cione (2012): 2012 operational HWRF run retrospectively for 2011 storms **under-cools** relative to buoy composites

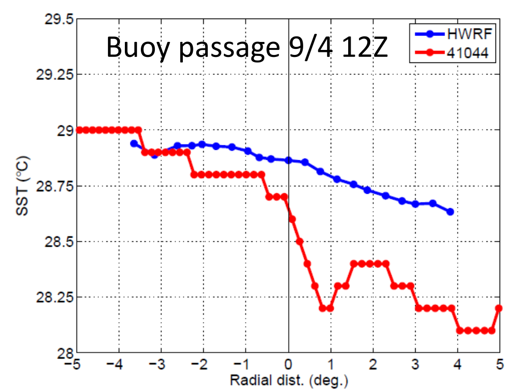
Example: Katia initialized 09/01/2011, 12 UTC



Reasonable track forecast



Good intensity forecast

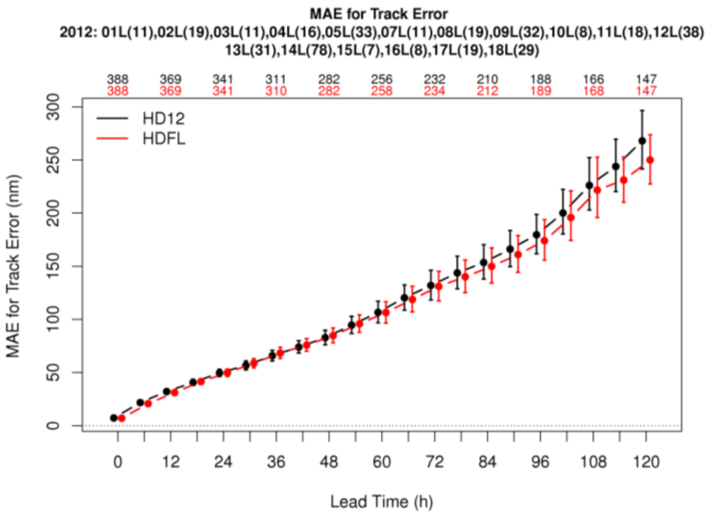


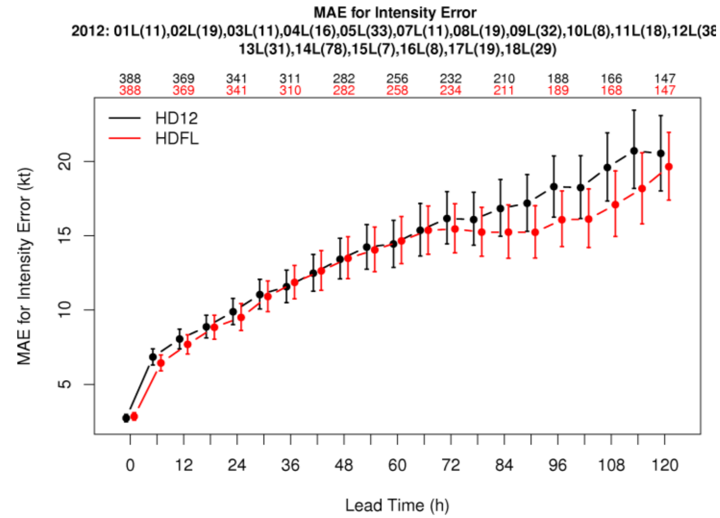
Poor ocean cooling forecast

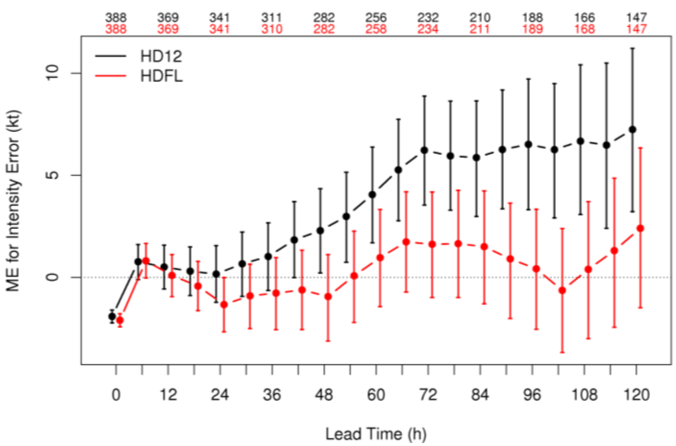
HWRF Testing

- Hypothesis (URI): flux reduction in HWRF not necessary (and should be eliminated as it is mostly non-physical)
- Comprehensive test: 2012 HWRF with (HD12) and without (HDFL) flux reduction. Cases: entire 2012 season
- Test supports HWRF operational implementation
- Case study (Leslie 09/04 00 Z)
  - Isolation of influence of flux reduction versus initial conditions
    - Note that HWRF is cycled, so IC for a given case are not identical between HDFL and HD12
  - Understanding of non-linear physical processes involved

Atlantic track and intensity

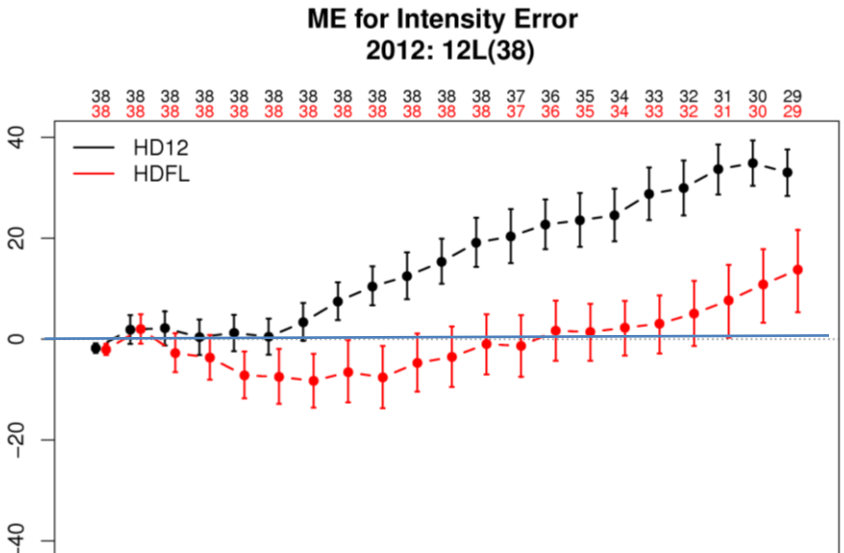


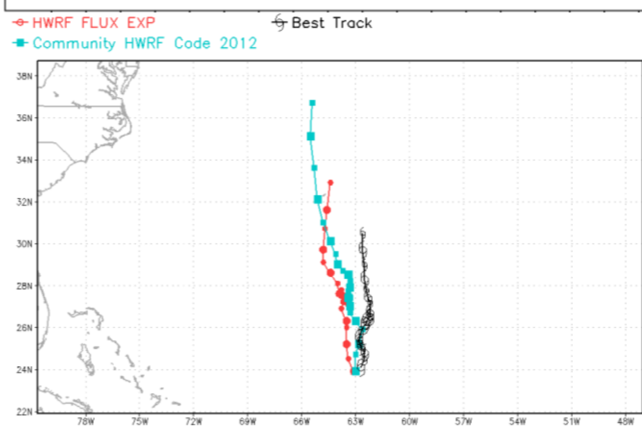


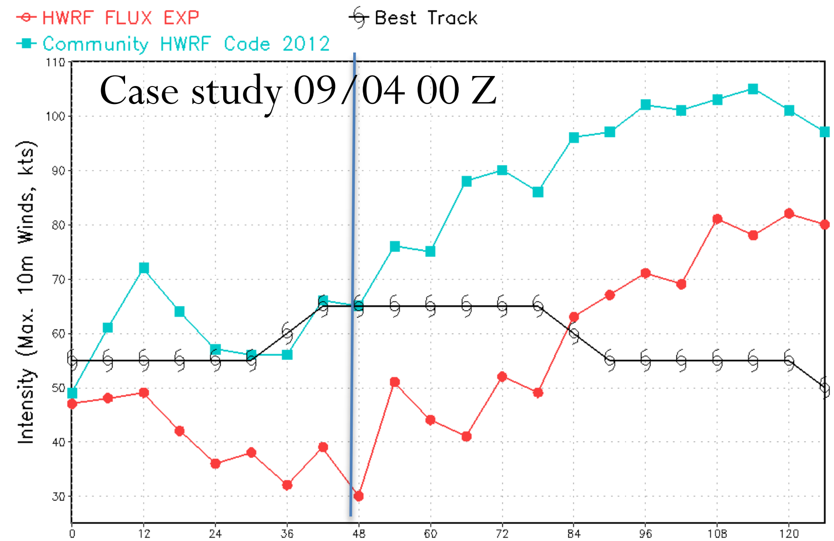


Track ME: HD12 and HDFL very similar
Int MAE: HDFL SS better at 3 lead times
Int bias: HDFL lowers intensity and helps overintensification at long lead times
Hurricane Leslie (12L) is the storm with largest impact (large and slow)
Pacific impact is much smaller (POM-TC 1D)

Largest impact: Hurricane Leslie

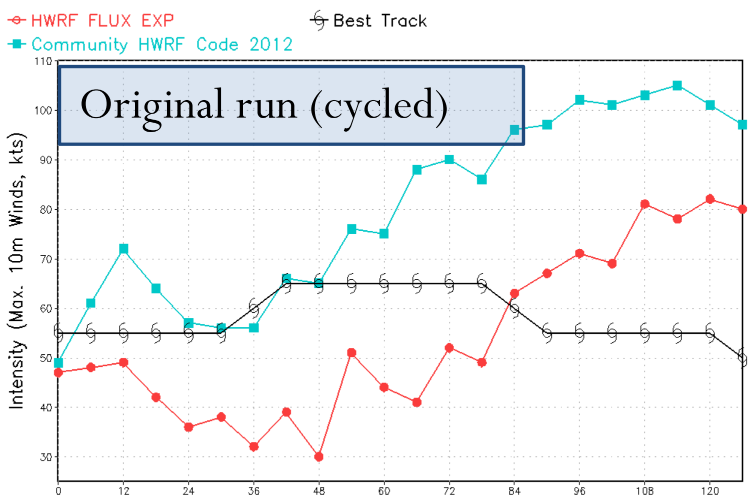


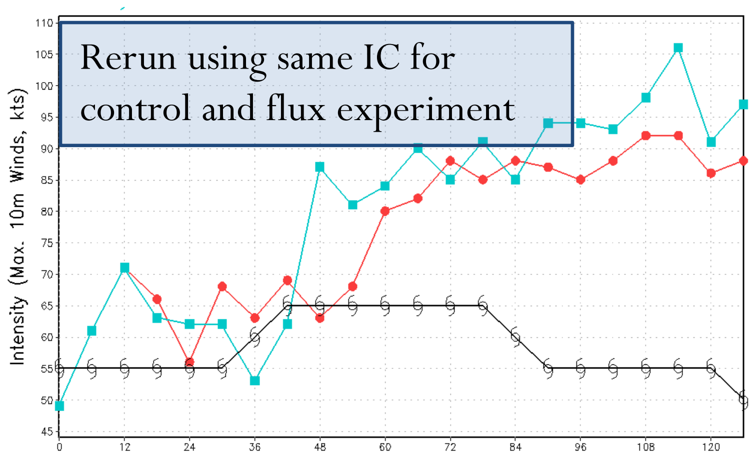




- HD12 and HDFL tracks are similar
- HDFL reduces intensity (as expected)
- Case study: 09/04 00 UTC HDFL has lower intensity

Leslie: rerun with same IC 09/04 00Z





Question: How much of the difference between HDFL and HD12 for a given case is due to fluxes change as opposed to sensitivity to IC?

Method: Ran with same IC

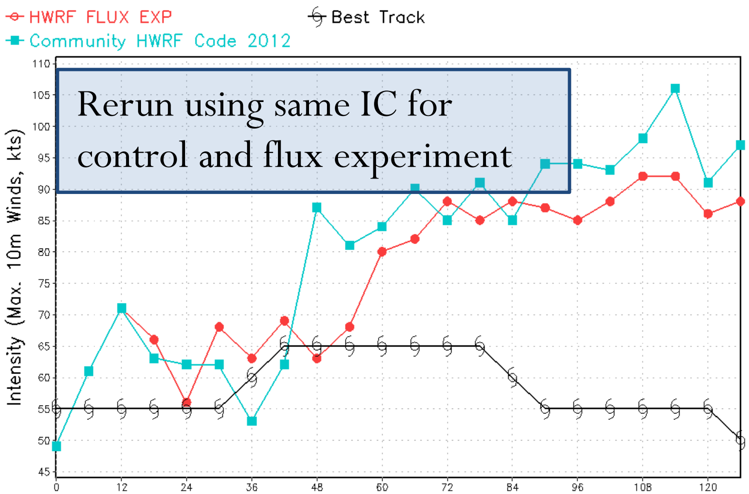
Answer: When same IC are used, differences between HD12 and HDFL are much smaller

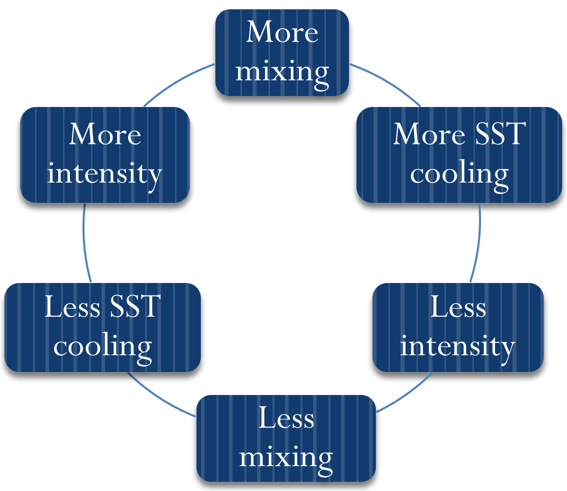
Forecast differences are highly influenced by IC in addition to flux differences

In each run, different fluxes make a small difference, which gets compounded by cycling

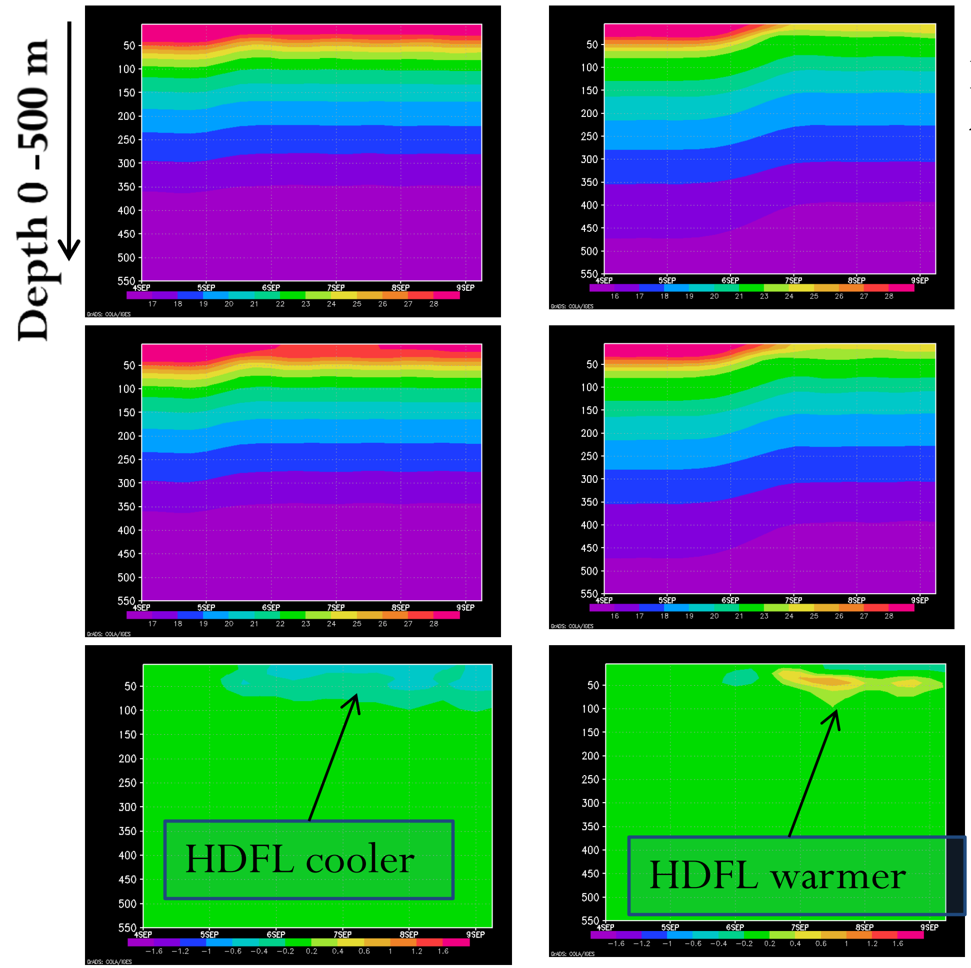
Caution should be used when differences between a pair of runs are analyzed!!

Nonlinearity in ocean response





Location X (24 h) Location Y (48 h)



HD12 temp

HDFL temp

HDFL -HD12 temp

0-120 h forecast

Conclusions

- Physically-based fluxes in 2012 HWRF improve AL intensity
  - 2012 HWRF has 3-km grid spacing, revised PBL and C_d, C_h, therefore physical processes are better represented
- This work demonstrated new collaborations and process
  - NOAA AOML/HRD conducted model evaluation
  - URI helped formulate hypothesis
  - DTC conducted extensive testing and case
  - HRD conducted additional verification and diagnostics studies (not shown)
  - Change accepted by EMC for HWRF 2013
- Test plan for 2013 yet to-be-determined with partners , likely
  - Thompson microphysics with RRTMG
  - Noah land surface model